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Automatic differentiation of pulmonary artery and vein using modified tree reconstruction algorithm from volumetric chest CT

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The automated segmentation and classification of pulmonary vein and artery at chest CT are necessary to assess the status of pulmonary circulation status in many diseases. The purpose of this research is to develop and validate our new method about automated segmentation and classification using modified tree reconstruction algorithm from point clouds.

For this work, a set of voxels first estimated as included in the pulmonary vessel was automatically extracted from a volumetric chest CT scan. One global tree structure was constructed from a point cloud by iteratively constructing a weighted minimum spanning tree (MST) with a globally optimized orientation vector field from the MST until it converges. The geometric node positions of initial MST were refined for its neighbor edges to have the same direction with the orientation field, and then they were merged for the simple topological structure. All the steps were accomplished using global optimization to minimize a cost function. Each tree branch was labeled with increasing value by going from peripheral leaf node to the root in the mid-mediastinal part, combined with its geometric length. By extracting child branches only in more than a certain level, separated artery and vein segments could be successfully obtain. All the steps are possible to be conducted automatically with a parameter value to extracting sub-branches, or semi-automatically by setting the region to cut out.

For the evaluation, 10 chronic obstructive pulmonary disease (COPD) non-contrast volumetric chest CT scans with sub-millimeter thickness were used. A 10-year-experience thoracic radiologist assessed the accuracy of automated classification results of 3 segments in right upper lobe using 10-scale grading system (score, accuracy percentile %; 5, < 50 ; 6, ≥ 50; 7, ≥ 60; 8 : ≥ 70; 9 : ≥ 80; 10 : 90~100). The performances were 8.6 ± 0.69, 8.6 ± 0.69, and 7.5 ± 0.85 (mean $\pm$ SD) for the apical segment, posterior segment, and anterior segment, respectively.

With the quite reasonable clinical result, this full or semi-automatic classification method for pulmonary vessel structures may be useful in assessing many pulmonary disease such as pulmonary hypertension, interstitial lung disease and COPD.